Nonfunctional Requirement

Reliability: definition and measurement

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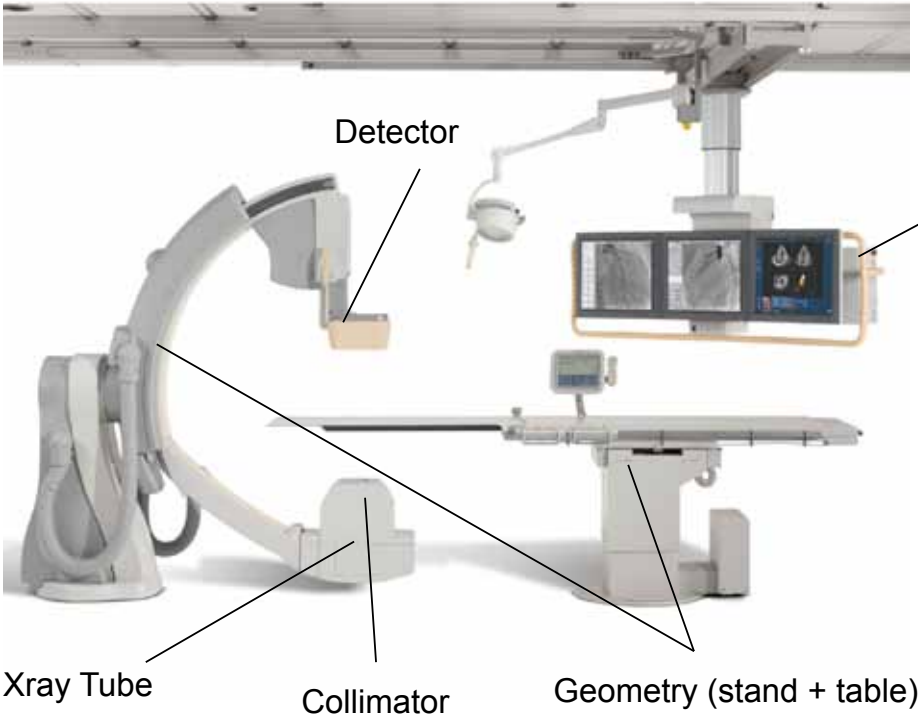
iXR monoplane system



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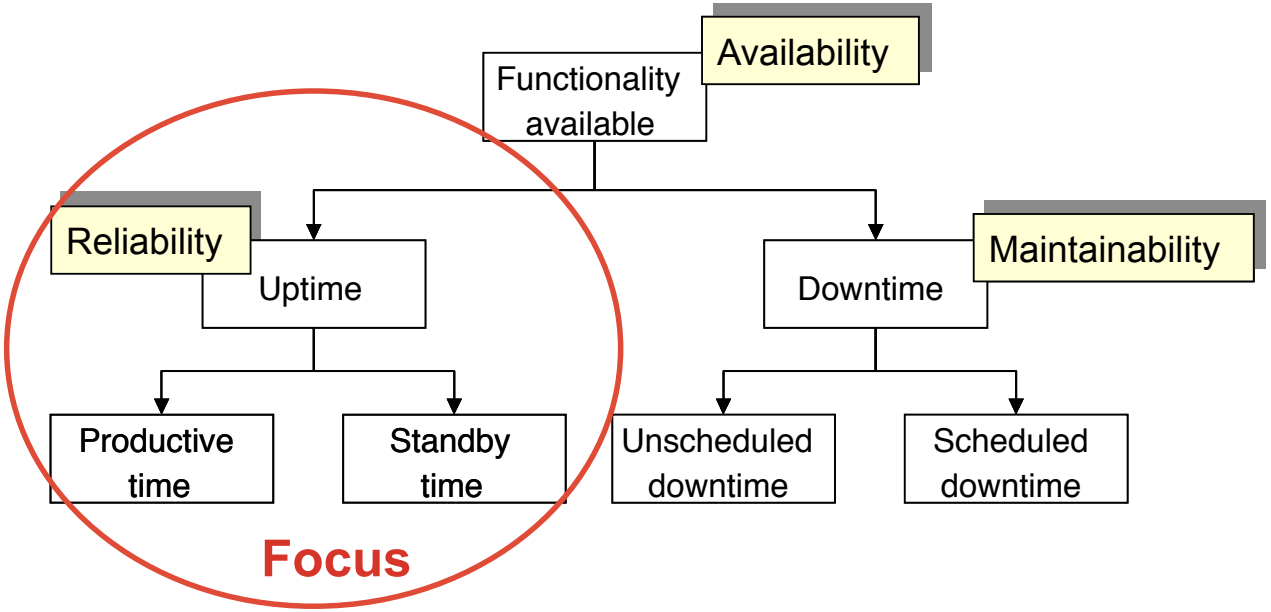
What is Reliability?

Part of availability



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What is Reliability?
System Reliability

Reliability is the probability that a system will perform

- all intended functions
- under stated conditions in a specified environment
- without failure
- during a specified time

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What is Reliability?
Software Reliability

- The capability of the software product to maintain a specified level of performance when, used under specified conditions (*from ISO/IEC 9126: software engineering/product quality*)

- The ability of a system or component to perform its required functions under stated conditions for a specified period of time (*IEEE standard glossary of software engineering terminology*)

- The probability of failure-free software operation in a specified environment for a specified period of time (or natural units) (*from AppTech course on SRE*)

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Requirements
Conditions aspects

Reliability - the probability that the system will perform its intended function, **under stated conditions**, without failures for a specified period of time

- **Under what (use) conditions should the software function?**
  - HW:
    - temp., humidity, vibration, … patients/hr, scans/hr, …
  - SW:
    - (Variation in the) Order in which functions are performed (use cases)
    - Variations in the input (e.g. also due to variation in the hardware), availability of resources (processor time, memory, etc)
    - In general: what possible exceptions/variations are likely to occur
  - These conditions/exceptions/variations stress the system

- **What are the ranges for these stress conditions?**
  (Quantify limits of application conditions)

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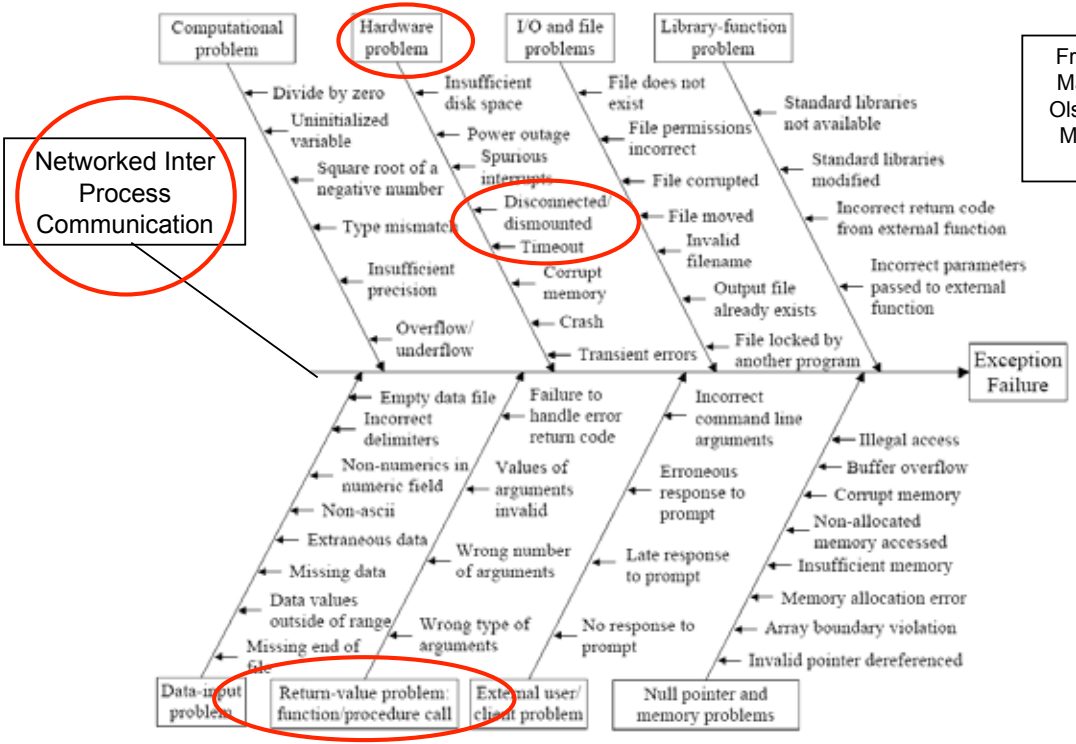
Categorized overview of possible exceptions



From paper by Roy Maxion and Robert Olszewski (Carnegie Mellon University), 1998

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Requirements
Failures

Reliability - the probability that the system will perform its intended function, under stated conditions, **without failures** for a specified period of time

- Reliability Failures can be divided in 2 main categories
  - 'Hard' failures:
    - The system malfunctions (out of spec) and one or more components need to be replaced or adjusted.
  - 'Soft' failures
    - Strictly the system works according to (our) spec, but the user is not satisfied and claims the system 'malfunctions'.
- Examples
  - Failure occurs but can be fixed by re-booting the system
  - Failure occurs but the function is automatically restarted in the background
  - Same and the user does not notice the failure
  - System 'fails' because user does not fully understands how things work
  - System sends job to printer and it fails because printer is not configured correctly

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Requirements
Time aspects

Reliability - the probability that the system will perform its intended function, under stated conditions, without failures **for a specified period of time**

- 3 aspects
  - What is the expected lifetime of the system?
  - What is the appropriate 'time' unit?
    - Calendar hours, usage hours or natural units, such as number of output pages, X-Ray images, transactions, queries, …
  - How many failures are allowed per 'time' unit?
    - May be different for various (critical) functions
    - What is the appropriate way to express this?
      - Failure rate
      - MTBF
      - Metrics related to the prob distribution of the failure times

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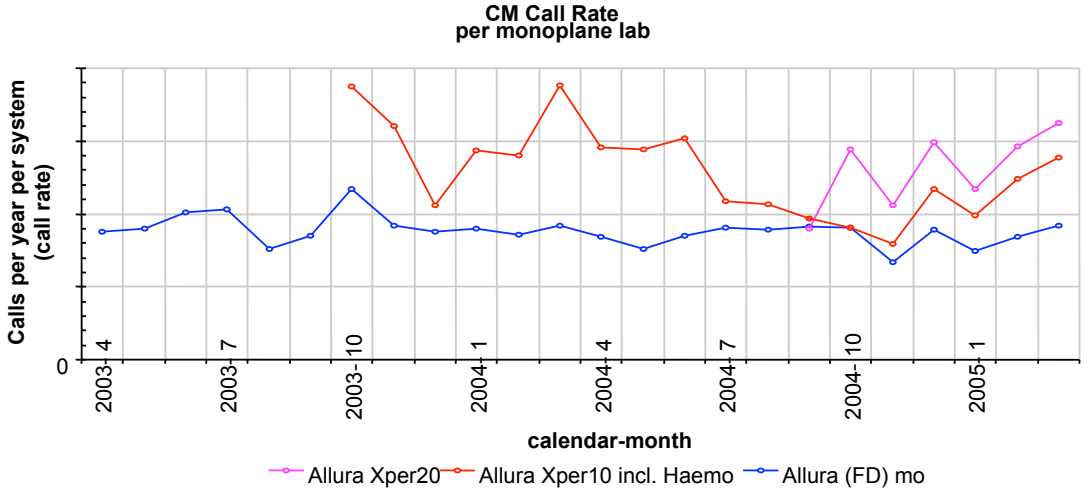
Measurement in practice
Calls

System/Site Info				Calls						
Config ID	*Site Adress*	*Hospital Name*	*Install Date*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*
x	City X	Hospital X	Dec	x1	x2	x3	x4	x5	x6	x7
y	City Y	Hospital Y	Jan		y1	y2	y3	y4	y5	y6
z	City z	Hospital Z	Mar				z1	z2	z3	z4
Average				<X>(jan)	<X>f(eb)	<X>(mar)	<X>(apr)	<X>(may)	<X>(jun)	<X>(jul)



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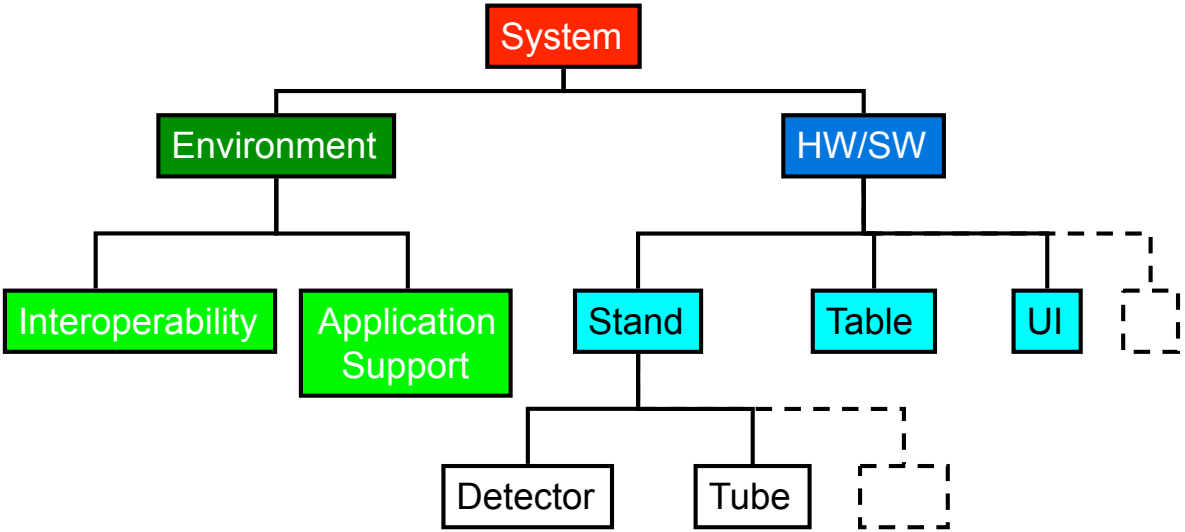
Measurement in practice

Assigning calls to 'subsystems/components'(1)



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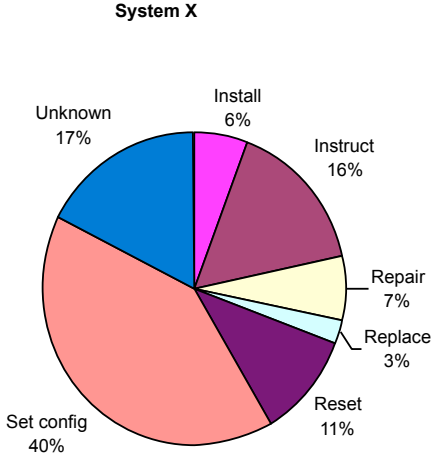
Measurement in practice

Assigning calls to 'subsystems/components'(2)



System Type PBL	Warranty				
	Faiure Rate	MTBF (hrs)	Labour (hrs)	Material (€)	Annual Cost (€)
Total System	**X**	**Y**	**Zl**	**Zm**	**Ztot**
HW/SW	**x1**	**y1**	**zl1**	**zm1**	**ztot1**
Stand	x11	y11	zl11	zm11	ztot11
Detector	x111	y111	zl111	zm111	ztot111
Tube	x112	y112	zl112	zm112	ztot112
Rest					
Table	x12	y12	zl12	zm12	ztot12
Height Movement					
Table Top					
Rest					
UI's	x13				
TSM					
Rest					
Environment	x2	y2	zl2	zm2	ztot2
Interoperability					
Application Support					
Rest					

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Measurement in practice
Software failures

- How to measure SW failures?
- Issues
  - When is it a HW, and when a SW failure?
    - Information in calls (and RCA of returned parts) is insufficient to assign
  - In case of SW failure, is it noticed by the user or not?
    - User hardly calls i.co. SW failure, than it is fixed by re-start
    - Persistent problems are reported by Field Problem Report (FPR)
      - Could be a SWR metric
  - How to deal with ‘collateral damage’?
    - A SW failure deep down in the system often triggers many other failures on high levels
    - How to distinguish and how to count?

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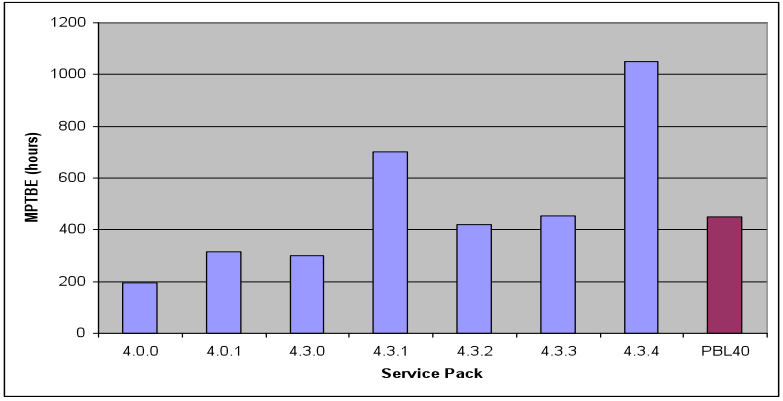
Measurement in practice
Software failures

- Important source for SWR failures are system event logs
- Not yet easy to mine due to poor content
  - To rich
  - Changes over time
- We are in the process of defining event logs as well defined interface



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Measurement in practice
Leading metrics (HW)

- In design phase
  - In HW dominated systems often a breakdown or decomposition of the ‘expected’ failure rate can be made
  - What to do with ‘Soft’ failures?
  - RPN from FMEA may be an early metric
    - Problem: how to compare various parts of the system from separate FMEA’s
- During verification
  - In a well organized Reliability Growth testing program the MTBF can determined and extrapolated
    - Problems: definition of failures and relation to real usage and user reaction

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Measurement in practice
Leading metrics (SW)

- Defect Trend
  - History of total nr of problem reports per defect status
- Maturity Grid
  - Visual presentation of defects with their severity and status to support quality gate decisions (e.g. release product, progress to next phase) of the product under development
- MTBF
  - Mean time between failures, measured as part of a reliability growth plan using operational profiles that realistically represent use in the field

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Metrics on Serviceability
Focus on Diagnosability

- **Number of (re)visits per call**, indicates the difficulty in determining the root cause (could not be detected or solved in the first visit or remote).
- **Multiple parts used per call**, indicates that several parts (or root causes) were thought possible and the exact failing part (or root cause) could not be pinpointed.
- **No Defects Found**, parts that were replaced but turn out, after testing, to have no failures (wrong part replaced?).
- **Good returns**, parts that are ordered by the FSE, but which are sent back since these were not required to fix the problem. A large number of parts ordered (and returned) indicates that the FSE does not know what will solve the problem, he is “gambling” upfront.
- **Deviation in TTR**, A large deviation indicates that not in all cases (or by all FSE’s) the root cause could easily be found (process not under control). A large standard deviation in TTR indicates opportunity to bring MTTR down.
- **Mean Time to Repair,** a large MTTR compared to the expected value may indicate that the root cause cannot be found as easily as required.

- **KPI-1:** **(Re)Visit Rate** = #Visits/Call
- **KPI-2:** **Find (FRU Isolation Index)** = #Parts Consumed / (#Good Returns + #No Defect Found + #Parts Consumed)
- **KPI-3:** **Mean Time to Repair**
- **KPI-4:** **Standard Deviation of TTR over MTTR**


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